The Rev. JOHN H. JELLETT read a paper—

ON A NEW OPTICAL SACCHAROMETER. (PLATE XXII.)

THE author said that his attention had been directed to the possibility of applying the new analyzing prism, the construction of which he had described to the Academy some time since, to the construction of a saccharometer, capable of giving more accurate results than those obtainable by means of the instrument of Soleil. Having described this latter instrument, he said that, as far as he could judge, both from his own experiments and the report of others who had used it, the error to which even an accurate observer would be liable in attempting to estimate the strength of a saccharine solution, could not be reckoned as less than half a grain per cubic inch for a single observation. Having stated what he believed to be the cause of this want of accuracy, the author exhibited and described the instrument which he had himself devised for the same purpose. Of this instrument, the accompanying diagram (Fig. 1) is a representation.

aa is a short tube, containing two large lenses, serving to condense the light of a lamp, which is placed as nearly as possible in the principal focus of the lower lens. *bb*, *cc*, is a short tube, carrying at one extremity a lens, *cc*, and at the other extremity a diaphragm, *bb*, pierced at its centre by a very small hole, *O*, which is situated in the principal focus of the lens *cc*, and also, when the instrument is adjusted, in the principal focus of the upper lens *a*. By this arrangement a beam of light is obtained emerging from *cc*, sensibly parallel to the axis of the tubes. This beam is polarized by being transmitted through a Nicol's prism, contained in the tube *dd*. *ee* is a vessel, pierced at the lower end by a circular hole, which is closed with plate glass. This vessel contains a fluid, possessing a rotative power opposite to that of the fluid under examination. This latter fluid is contained in the tube *ff*, which rests on the two upright pieces *yy*. These pieces are attached to the transverse piece *vv*, which carries a vernier, whose divisions correspond to those of the scale, *ss*, which is attached to the bar *zz*, which carries all the parts of the instrument. The transverse piece, *vv*, is capable of sliding along *zz*, this motion being produced by a chain, attached at both ends to *zz*, passing round a spindle with a matted head, attached to *vv*. By these means a motion can be given to the tube *ff* parallel to its own axis; and, by a very simple arrangement, the zero of the vernier is made to coincide with the zero of the scale, when the extremity, *f*, of the tube is in contact with the piece of glass covering the lower aperture in the vessel *ee*. It is plain, then, that the numbers read on the scale, which is graduated so as to be read to 0 inch ·001, will denote the length of the column of fluid *E F* (Fig. 2) interposed between the bottom of the vessel and the bottom of the tube. *gg* is an analyzing prism, constructed as before described.* *hh* is a lens, and *l* a diaphragm, with a small hole, at which the eye of the observer is placed. The polarizing and analyzing prisms are fixed in their places by small screws, σ, σ', each passing

* "Proceedings of the Royal Irish Academy," vol. vii., p. 348.

through a transverse slit in the outer tube, so that when partly unscrewed they allow the prisms to turn through a small angle round the axes of the tube. In using the instrument, the polarizing prism may be set in any position, the analyzing prism being then carefully adjusted, so that the tints in the two halves of the circular spectrum* may, when there in no fluid interposed, be exactly equal.

Suppose now that the object is to ascertain the strength of a given solution of cane sugar. In this case, the fluid to be used in the vessel, *EE*, may be French oil of turpentine. A certain quantity, the amount of which depends on the strength of the solution to be observed, having been poured into the vessel, the tube, *ff*, is then filled with a solution of sugar, whose strength is accurately known. The tube is now replaced in the upright pieces, and the zero of the vernier made to coincide accurately with the zero of the scale. The milled head is now turned so as to draw back the tube until the tints on the two parts of the circular image, seen through *L*, become equal. The number on the scale corresponding to the zero of the vernier is then noted. Let this reading be *R*, and let *S* be the strength of the known solution.

Now, let this solution be removed from the tube, which is then to be filled with the solution whose strength is required. The same process having been gone through, let the new reading be R'; then the strength required is given by the equation—

$$S' = \frac{R'}{R} \cdot S.$$

If the experiment be carefully conducted, and if there be no error in the strength of the standard solution, the error in the measurement made, as above described, ought not to exceed 0 grs. ·02 per cubic inch for a single experiment. If the mean of a number of experiments be taken, the error would, of course, be still less.

The author has given to this instrument the name saccharometer, derived from one important use to which it may be applied. This, however, is but one of its applications; and there are many others, at least as important. It may generally be defined to be an instrument by which the ratio of the rotatory power of any transparent fluid to that of a standard fluid may be accurately determined.

It is not desirable to use a very strong solution of the substance to be examined. The reason of this is the imperfect compensation which exists between fluids possessed of opposite rotatory powers. It is generally assumed that the ratio of the rotation produced in the planes of polarization of any two of the simple rays of which a white ray is composed is the same, whatever be the substance causing the rotation. It follows, indeed, from the law of Biot, that this is not accurately true, but it has been generally supposed that the error is too small to be perceived. If this were true, it would always be possible to assign to the lengths of two columns of oppositely rotating fluids such a ratio, that the effect of the one should be accurately compensated by the effect of the other.

---

* Proceedings of the Royal Irish Academy, vol. vii., p. 349.

But the author has found that in certain cases the error is very perceptible indeed. This is shown by the impossibility of giving to the tube *ff* any position in which the shades of colour are exactly the same in the two parts of the circular image. Suppose, for example, that the position of the tube is such that the plane of polarization of the mean ray has the same position as at first. This plane is then equally inclined to the planes of analyzation of the two parts of the analyzing prism. But this is not true of the planes of polarization of any of the other rays; of these, the less refrangible will have their planes of polarization nearer to one of the planes of analyzation, while those of the more refrangible are nearer to the other.

There will therefore be in the one half of the image a preponderance of red light, and in the other a preponderance of blue light, when the intensities of the two parts are equal. The difference of colour, which makes it difficult to equalize these intensities with perfect accuracy, will evidently be greater, the greater the amount of the rotations which the compensating fluids would severally produce, and therefore the greater the strength of the solution.

On the other hand, it must be remembered that the error in the result, arising from an incorrect position of the tube, is inversely proportional to the length of the column of the compensating fluid. Thus, if the reading of the scale be ·1, an error of one division, or ·001 will have the same effect on the result, as an error ten times as great would have, if the reading were 1·000.

No general rule can be given for determining the strength of the solution which it is desirable to use. If the law of Biot, sc.,—that the amounts of rotation produced by the same substance in the planes of polarization of the different simple rays are proportional to the squares of the corresponding refractive indices—be strictly true, then, the more nearly these indices are in the same proportion for the fluid under examination and the compensating fluid, the stronger may be the solution used. If the fluid under examination be a saccharine solution, and the compensating fluid French oil of turpentine, a solution containing, in each cubic inch, thirty grains of sugar, may be used without inconvenience.*

James Dombrain, Esq., of Monkstown, through Gilbert Sanders, Esq., presented a very perfect long tapering sword-blade, made of bronze, found in a bog, near Timoleague, county of Cork.

Henry Kingsmill, Esq., on the part of his son, Henry Kingsmill, Jun., Esq., presented a collection of rubbings from monumental brasses.

The Master of the Rolls in England, through the Librarian, presented a large collection of Record publications, completing the series already in the Library of the Academy, and consisting of 63 volumes.

The thanks of the Academy were presented to the donors.

* The instrument here described was constructed by Messrs. Spencer and Son, of Aungier-street, to whose ability, both in carrying out the instructions given to them, and in suggesting methods for overcoming practical difficulties, the author is much indebted.

Fig. 1.

Fig. 2.